

expand more there than on the opposite side. This in turn causes the spindle to bend and the spindle is thus thrown sufficiently out of truth to cause the running blades to foul the fixed ones. The only safe way to heat up a turbine is to pass comparatively big quantities of steam through it and then to shut the steam off for a short period, thereby ensuring a uniform distribution of steam throughout the blading spaces. These gusts of steam can be repeated say once every half-minute for ten or fifteen minutes, by which time the turbine can be started up.

The impulse turbine is somewhat easier to start up than the reaction turbine. The impulse turbine does not require so long a time to get warm, and can be started up direct from cold without danger. The reason for this is that the hot steam is never allowed to come into contact with the big masses of metal as is the case with a reaction turbine, so that it is quite a common thing for an impulse turbine to be run straight up on load without any previous heating up. Should the turbine be designed so that it runs through a first critical shaft speed, and its normal speed is say 3000 r.p.m., its first critical speed will probably be somewhere round about 2000 to 2400 r.p.m. The proper procedure is to give the turbine sufficient steam to start it moving, and to allow it to run up to a speed of approximately 1500 r.p.m. quite slowly. When that speed has been reached and the operator is quite satisfied that the machine is ready to go on load, he should then open the stop valve freely, allowing the machine to run up to its normal speed as quickly as possible, thereby making sure that the turbine is not allowed to dwell on the first critical speed under any circumstances whatever. If the turbine rotor is allowed to revolve at its critical speed for any length of time, any little external vibration that happens to exist and to synchronize with the critical frequency may cause the spindle to run out of truth. This slight bend in the spindle will develop more and more at every rotation until it is sufficient either to strip the blading off the wheels or even to burst the casing. In its mildest form, this trouble may lead to a permanent

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It might be gathered from the above remarks that the impulse type of turbine is the better machine for power production. This is not necessarily the case. Other factors have to be taken into account in deciding which is the better type for any particular purpose.

It has been found that much less risk and expense is incurred by keeping a machine on load than by shutting it down and starting it up again if it is likely to be off load only for two or three hours at a time. The bulk of the troubles from which steam turbines suffer, develop during the period of starting up. This is due to the difficulty of obtaining uniform expansion of the masses of metal in the machine. Even when the greatest care is exercised, it is almost impossible to admit the steam in the same manner

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